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Aquatic macrophytes of Northeastern Brazil: Checklist, richness, distribution and life forms

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Abstract: Aquatic plants have great influence on the structure and dynamics of aquatic ecosystems, thereby contributing considerably to biodiversity. In Brazil, knowledge of the biodiversity of aquatic macroflora is still limited. We present a checklist of aquatic macrophytes occurring in the northeastern region of Brazil through a bibliographic search. We recorded a total of 412 species, 217 genera and 72 families. The most representative families were Cyperaceae (70 species), Poaceae (38), Fabaceae (27) and Asteraceae (20). The States with highest number of species were Pernambuco (370), Bahia (360), Ceará (267) and Paraíba (261). The best-represented life forms were amphibious (193 species) and emergent (100). The aquatic flora of Northeastern Brazil exhibits high species richness; however, there is a scarcity of records of aquatic macrophytes for the States of Alagoas, Rio Grande do Norte, Maranhão, Sergipe and Piauí.

Introduction

Wetlands represent one of the vital components in the maintenance of the global balance, considering the high diversity of species found in these ecosystems (Gopal and Junk 2000). Part of this biodiversity can be explained by the presence of aquatic plants, which are known to exert large structural and metabolic influences on the environment. These plants participate in the production of organic matter and nutrient cycling in the water, constitute the base of the food chain as the primary source of energy, protect the margins of rivers, ponds and lakes against erosion, and serve as shelter and protection for aquatic and/or amphibious organisms (Pott and Pott 2000; Murphy *et al.* 2003; Thomaz and Cunha 2010). On the other hand, the excessive growth of aquatic vegetation (mostly ruderal species) can become a problem for water use (navigation and electric power generation), contributing to loss of diversity of submersed plants and phytoplankton (Lembi 2009; Thomaz and Cunha 2010).

Throughout the world, the first studies on aquatic macrophytes were performed in temperate ecosystems and only later began to be performed in the tropics (Thomaz and Bini 2003; Pompêo and Moschini-Carlos 2003). Due to this geographic bias, the existing literature on aquatic plants of tropical regions does not correlate with the biodiversity of the group. Even now, few works address the biodiversity of aquatic macrophytes in African (Raynal-Roques 1980; Obot and Mbagwu 2008) and Asian countries (Subramanyam 1962). In the Americas, studies have been performed in Mexico (Ramos and Novelo 1993; Bonilla-Barbosa and Novelo 1995), in Argentina (Neiff 1982; Lahitte and Hurrell 1996; Miretzky *et al.* 2004), in Paraguay (Mereles *et al.* 1992; Neiff *et al.* 2000), and in Venezuela (Vilarrubia and Cora 1993).

In Brazil, the analysis of biodiversity of aquatic macrophytes has been restricted to the South, Southeast and Central-West regions and some sporadic studies developed in other regions (Thomaz and Bini 2003). Irgang and Gastal-Jr. (1996) published a list with identification keys and photos of approximately 400 species of aquatic macrophytes of the coastal plain of Rio Grande do Sul. Scremin-Dias *et al.* (1999) produced an identification guide of ca. 50 species of aquatic plants occurring in Bonito and Bodoquena. Pott and Pott (2000) presented brief morphological descriptions, ecological aspects, geographic distribution and simplified identification keys of 246 species of aquatic macrophytes found in the Pantanal. Recently, Amaral *et al.* (2008) published a field guide for aquatic and palustrine plants of the State of São Paulo, including the description of ca. 400 species, plus illustrations.

Knowledge of the aquatic macroflora of the Northeast of Brazil is also quite limited. Some floristic studies were carried out by Matias *et al.* (2003) in Ceará, by Neves *et al.* (2006) in coastal lakes in Bahia, and by França *et al.* (2003), also in Bahia. In the State of Pernambuco, Sobral-Leite *et al.* (2010) presented a checklist of vascular macrophytes, Lima *et al.* (2009) made a floristic survey of herbaria, and Moura-Júnior *et al.* (2009) compared the richness of aquatic macrophytes among water supply reservoirs. Pompêo and Moschini-Carlos (2003) observed that in spite of the growing number of studies, research and discussion

of aquatic macrophytes in congresses, symposia and scientific journals, there are few professionals that are currently fully dedicated to study this community in Brazil.

Although they have yet to cover the diversity of aquatic macrophytes, the floristic studies carried out in Brazil are important because they contribute to the quantification and qualification of the flora of aquatic ecosystems, as well as to the knowledge of geographic distribution of species. In such a context, obtaining a global vision of the quantity of records and of the species richness of aquatic macrophytes can serve as subsidy for ecological studies, can help visualize patterns related to biodiversity and can help elucidate the relation of flora with environmental factors.

Therefore, our study aims to produce a checklist of aquatic macrophytes occurring in the Northeast of Brazil through a bibliographic survey based on inventories in this region. Thereafter, we want to answer the following questions: (i) What is the number of species recorded for the Northeast of Brazil? (ii) What is the number of existing records for each State of the region? (iii) What are the life forms? (iv) What is the floristic similarity between the states? and (v) Which species are considered ruderal or opportunistic?

Materials and Methods

Study site

Distinguished from other tropical regions by certain peculiar aspects, the Northeast region of Brazil occupies an area of 1,554,257 km^2 (18.25% of Brazil) and contains nine states: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe (IBGE 2002) (Figure 1). This region is characterized by strikingly distinct phytogeographic zones (forest, subhumid and semiarid Caatinga, and middle North palmlands) and an annual regime of rain irregularly distributed between March and August, with the peak in May and June, the dry period being between September and February (IBGE 2002; Silva *et al.* 2002).

Covering a large drainage area of the Northeast region of Brazil, there are important Brazilian hydrographic basins, among which we note the following: São Francisco Basin, which has an area of 643,000 km^2 and covers 521 municipalities of seven states (Bahia, Minas Gerais, Pernambuco, Alagoas, Sergipe, Goiás and Distrito Federal); Parnaíba Basin, which occupies 344,112 km^2 nearly covering the whole state of Piauí and part of the states of Maranhão and Ceará; Oriental Northeastern Atlantic Basin, basically situated in the state of Maranhão and in a small oriental portion of the state of Pará, has an area of 254,100 km^2; and the Eastern Atlantic Basin, with an area of 374,677 km^2, within two states of the Northeast (Sergipe and Bahia) and two of the Southeast (Minas Gerais and Espírito Santo) (ANA 2012).

Data Collection

The checklist was created by a bibliographic search of studies on aquatic plants performed in the Northeast of Brazil, published between August 2000 and 2010. To accomplish these objectives, we adopted the conceptualization of aquatic macrophytes proposed by Cook (1996), in which the author includes plants in which photosynthetically active organs are either permanently or for several months of the year totally or partially submersed in freshwater or floating in aquatic habitats. More recently, Chambers *et al.* (2008) also included charophytes within the definition of macrophytes.

Aquatic macrophytes have been grouped according to their life forms into submerged, free floating, rooted floating, emergent and amphibious (Irgang *et al.* 1984), and epiphyte (Tur 1972). Usually, life form zoning occurs according to water depth: amphibians on the littoral, emergents on the shallow belts, and others in the deeper zones (Pott *et al.* 2011).

We consulted floristic and/or taxonomic work such as book chapters and national and international scientific articles, as well as theses and dissertations made available by graduate programs in Botany and Ecology (Table 1). You can see the locations studied in some states (Figure 1, Table 1), except those related to study of Matias *et al.* (2010), who were not available. Based on those publications, we compiled the floristic data (including ruderal taxa) of life forms of the aquatic macrophytes by state.

To consolidate the checklist, in addition to the referred bibliography, we verified the species records for each

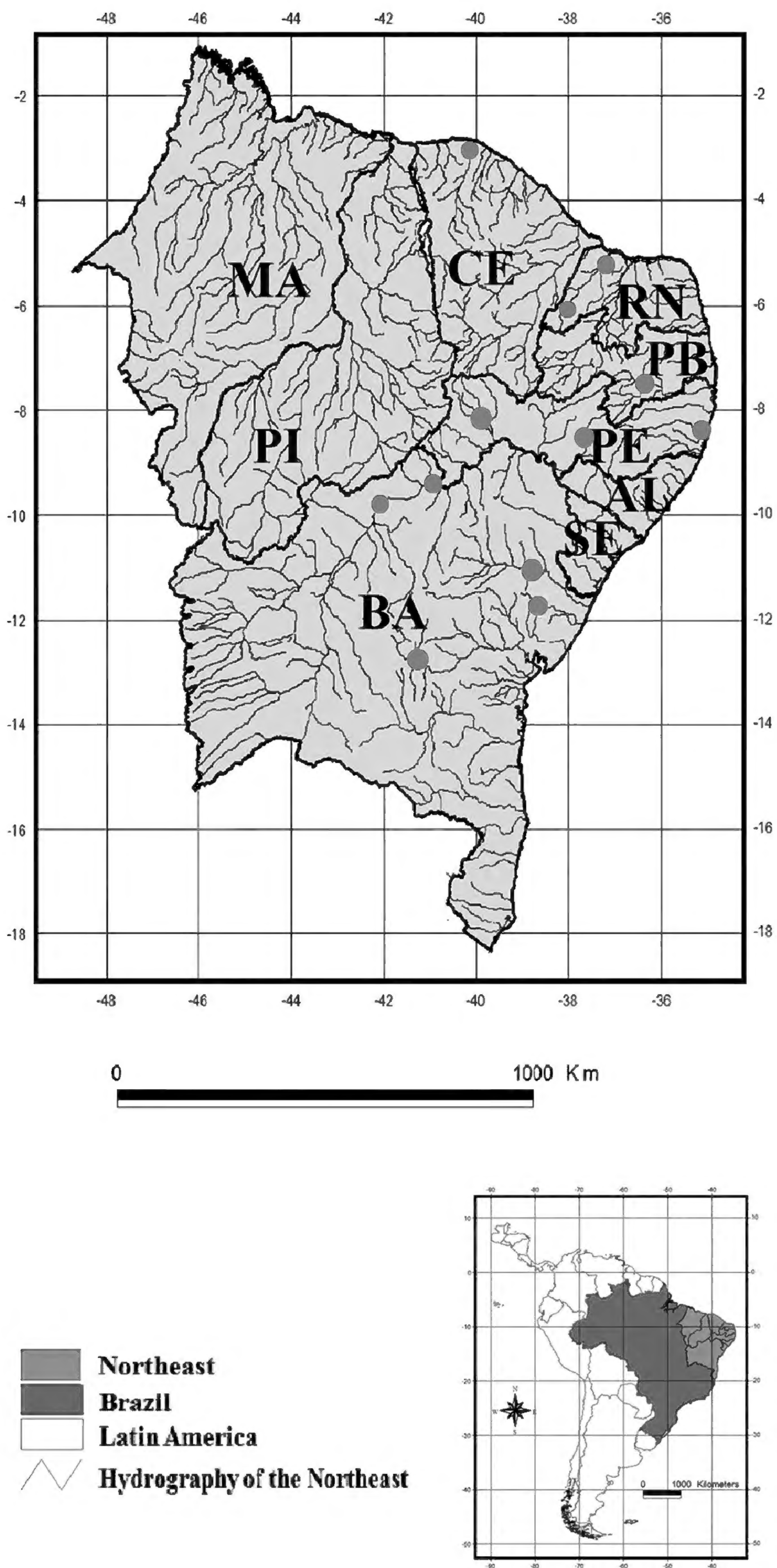

Figure 1. Hidrographic map of the Northeast region of Brazil, with the inventoried sites (in red). AL = State of Alagoas; BA = State of Bahia; CE = State of Ceará; MA = State of Maranhão; PB = State of Paraiba; PE; State of Pernambuco; PI = State of Piauí; RN = State of Rio Grande do Norte; SE = State of Sergipe.

state of Northeast of Brazil and consulted the biological collections on the data system of "speciesLink" (SPLINK 2011), which has information from the main Brazilian herbaria.

The species list followed the classification of families proposed by APG III (2009) for angiosperms, by Smith *et al.* (2006) for pteridophytes, Buck and Goffinet (2000) for bryophytes, and Wood and Imahori (1964) for macroalgae. Plant names and respective authors were checked by consulting the data bank of the Missouri Botanical Garden (MOBOT 2011). The characterization of species as ruderal was based on "Plantas daninhas do Brasil" (Lorenzi 2008), which considers species ruderal if they are the first to colonize disturbed wetlands.

Data analyses

The evaluation of the floristic similarity between the records of different states was accomplished through a cluster analysis. The date of floristic composition was subjected to an analysis of similarity by the Jaccard index (Magurran 2004) and ordered by the WPGMA method, using the software PRIMER 6.0 (Clarke and Gorley 2006). To identify significantly similar groups ($p < 0.05$), we used the Simprof method of randomization with 1000 replications, using the software PRIMER 6.0 (Clarke and Gorley 2006).

We compiled all records of aquatic macrophytes in a matrix of presence and absence of species. The frequency of occurrence of each species (F) was estimated through the equation:

$$F(i) = \frac{n_i}{N}$$

where:
n_i = number of sites where the species *i* was found, and
N = number of sampled sites

Table 1. List of the studies used to elaborate the checklist. AL = State of Alagoas; BA = State of Bahia; CE = State of Ceará; MA = State of Maranhão; PB = State of Paraiba; PE; State of Pernambuco; PI = State of Piauí; RN = State of Rio Grande do Norte; SE = State of Sergipe; NO = Northeastern.

AUTHOR(S)	STUDY REGION	TYPE OF ENVIRONMENT
Mathias and Nunes (2001)	CE	Coastal lagoon
França *et al.* (2003)	BA	Artificial pond
Matias *et al.* (2003)	CE	Coastal lagoon
Neves *et al.* (2006)	BA	Coastal lagoon
Pedro *et al.* (2006)	PB	River
Moura-Júnior *et al.* (2009)	PE	Artificial pond
Lima *et al.* (2009)	PE	Shallow lakes, rivers, floodplains, oxbow lakes, temporary ponds, permanent ponds, Coastal lagoons, lakes, permanent and temporary swamps, Artificial ponds
Nascimento (2009)	PE	Artificial pond
Henry-Silva *et al.* (2010)	RN	Rivers
Matias (2010)	NO	Shallow lakes, rivers, floodplains, oxbow lakes, temporary ponds, permanent ponds, Coastal lagoons, lakes, permanent and temporary swamps, Artificial ponds
Moura-Júnior *et al.* (2010)	BA	Artificial pond
Silva and Zickel (2010)	PE	Artificial pond
Sobra-Leite *et al.* (2010)	PE	Shallow lakes, rivers, floodplains, oxbow lakes, temporary ponds, permanent ponds, Coastal lagoons, lakes, permanent and temporary swamps, Artificial ponds

Results and Discussion

We compiled 412 species of 217 genera and 72 families (Table 2). According to Agostinho *et al.* (2005), the vascular aquatic flora of wetlands in Brazil is estimated to 600 species, which makes the number of taxa identified in our study somewhat representative. The high richness of aquatic macrophytes for the Northeast can be attributed to seasonal and hydrological influence on the aquatic ecosystems of the region (França *et al.* 2003; Neves *et al.* 2006; Moura-Júnior *et al.* 2009; Campelo *et al.* 2012)

The families with highest richness of aquatic macrophytes in the Northeast of Brazil were Cyperaceae, with 70 species, Poaceae (36 spp.), Fabaceae (27 spp.), Alismataceae (23 spp.) and Asteraceae (20 spp.) (Table 2). The floristic representativeness of Cyperaceae and Poaceae was also recorded in studies on aquatic macrophytes of the other Brazilian regions, including the North (Junk and Piedade 1993), South (Irgang and Gastal-Jr. 1996; Mormul *et al.* 2010) and Southeast (Ferreira *et al.* 2010). The present estimate is *ca.* 700 species of Cyperaceae and 1500 of Poaceae in Brazil (Souza and Lorenzi 2008). According to Goetghebeur (1998), the taxonomic abundance of these families must be related to their efficiency in vegetative propagation, with underground systems formed by rhizomes or stolons. The richness of Asteraceae and Fabaceae in our study converged with the result reported by Lima *et al.* (2009) in the checklist of aquatic macrophytes of the state of Pernambuco, wherein both of these families as well as the two previous families are the four richest. It is known that species of Asteraceae are particularly common in several vegetation types in Brazil (Souza and Lorenzi 2008), likely due to the morphological adaptations of the fruits, which have a persistent pappus transformed into a dispersal structure, primarily for anemochory and zoochory (Heiden *et al.* 2007). Considering Fabaceae, we believe that the morphological, ecophysiological and reproductive plasticity of the sub-families Faboideae, Caesalpinioideae and Mimosoideae can explain the wide specific richness of the family in ecotonal areas and in wetlands of the Northeast. As was discussed for Cyperaceae, Poaceae, Fabaceae and Asteraceae, the high representation of floristic Alismataceae in northeastern Brazil may also be related to morphological adjustments of their representatives. According to Matias (2010), individuals of *Echinodorus* and *Sagittaria* (the most common representative of Alismataceae in the study area) have

an underground system composed of perennial rhizomes with buds that can withstand long periods of drought and thus can colonize aquatic ecosystems permanently and/or intermittently until ecotone environments (swamps) are created.

The states which presented the highest number of records of species were Pernambuco with 369, Bahia (360 spp.), Ceará (267 spp.) and Paraíba (261 spp.). Next came the states of Alagoas with 208 species, Rio Grande do Norte (192 spp.), Maranhão (187 spp.), Sergipe (181 spp.) and Piauí (158 spp.). The number of species restricted to only one state also follows the pattern of total richness, the most representative being Pernambuco (24 spp.), Bahia (13 spp.), Ceará (3 spp.) and Rio Grande do Norte (2 spp.) (Table 2).

According to Magurran (1988), the number of inventoried species in an area invariably increases with the size of sampled area and/or the sampling effort. Therefore, the scarce record of aquatic macrophytes for the states of Alagoas, Rio Grande do Norte, Maranhão, Sergipe and Piauí compared to the other states of the Northeast might have been caused by the low number of inventoried areas and by a small range of studied areas. Although some states in the Northeast presented a negative bias regarding the record of aquatic plant species, Pernambuco and Bahia showed similar species richness to that observed in the Amazon region, where 388 species were identified (Junk and Piedade 1993), and higher than the richness of 273 species found in the Pantanal (Pott and Pott 2000).

According to the Simprof test, macrophyte communities that had Jaccard (S) scores above 54% were considered significantly similar in floristic structure (Figure 2). Thus, groups of species of aquatic plants in the states of Alagoas, Bahia, Ceará, Paraíba, Pernambuco and Sergipe can be considered similar (S = 55%) (Figure 2). However, within the group of those six states, there was the formation of three clusters whose similarity indices were the highest recorded in the analysis: the first included the aquatic macrophytes of the states of Bahia and Pernambuco (S = 79.8%), the second was represented by macrophytes of Ceará and Paraíba (S = 69.3%), and third was formed by hydrophytes of Alagoas and Sergipe (S = 58.5%) (Figure 2). Some studies have shown that the composition and distribution of species of aquatic plants in tropical ecosystems are primarily explained by their hydrological (e.g., elevation, flow) and/or limnological characteristics (e.g., turbidity, conductivity, transparency, pH, temperature and concentration of oxygen, nitrogen and dissolved phosphorus) (Thomaz *et al.* 2003; Murphy *et al.* 2003; Pedro *et al.* 2006; Souza *et al.* 2009;-Moura Júnior *et al.* 2011). Most of these researchers concede that changes in hydrological characteristics and/or limnological ecosystem changes, in short, the processes of interaction between species (e.g., competition, facilitation), modify the structure of aquatic communities. In this context, the similarity in the species composition of hydrophytes of Alagoas, Bahia, Ceará, Paraíba, Pernambuco and Sergipe can be explained by similarities in the hydrological and limnological conditions of aquatic ecosystems in these states. Similarly, the floristic dissimilarity of macrophytes of Maranhão, Piauí and Rio Grande do Norte in relation to other states of Northeastern Brazil is most likely related to the differences in hydrological and limnological ecosystem states. Moreover, the lack of information about the species of aquatic plants in the states of Maranhão, Piauí and Rio Grande do Norte may also explain the differences for these flora with the rest of the Northeast, which implies the need for floristic and taxonomic studies for these three states.

Regarding the aquatic macrophytes, which are restricted to only one of the life forms of the Northeast,

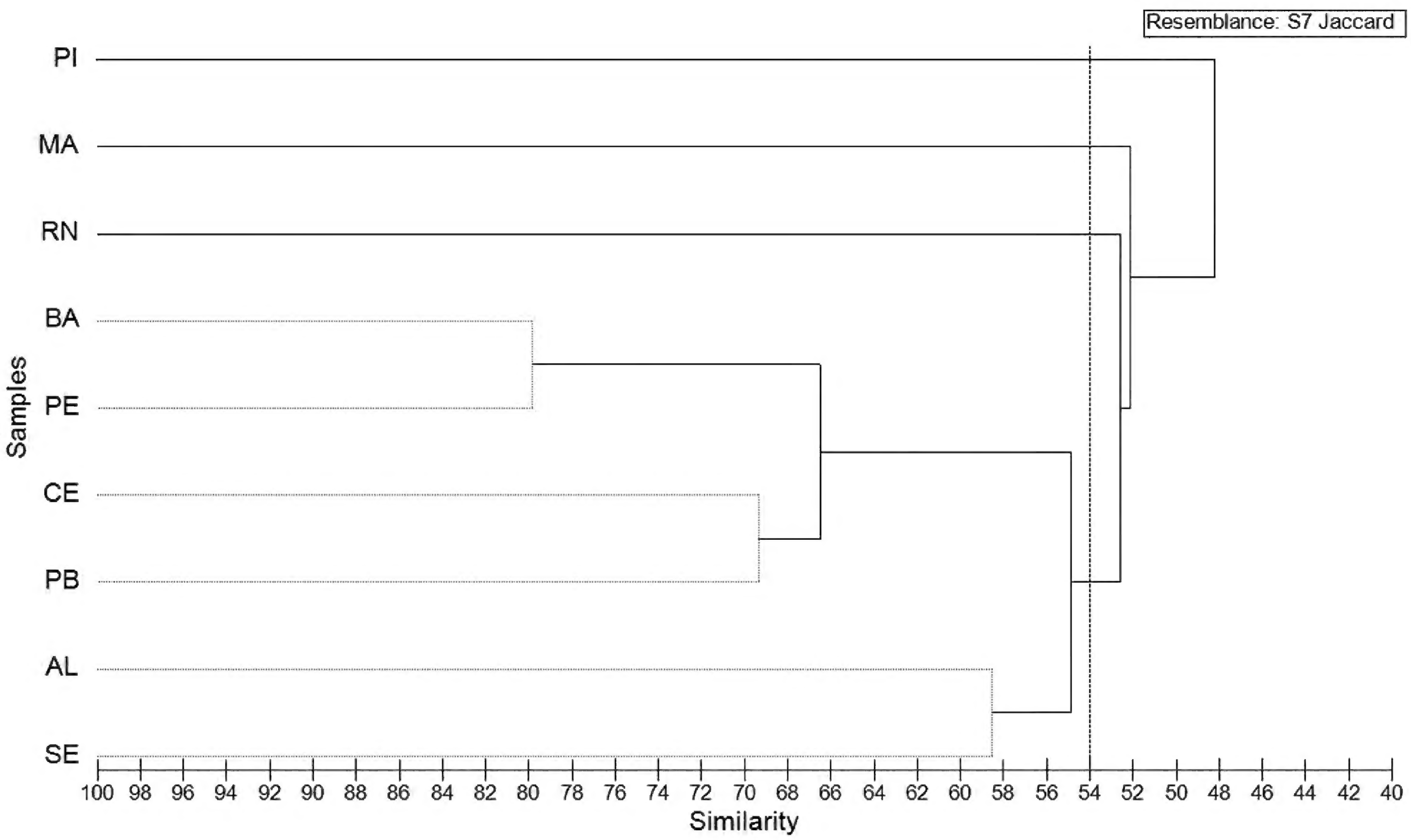

Figure 2. Dendrogram of floristic similarity (Jaccard coefficient) of aquatic macrophytes between the states, by Simprof randomization test = 54% (with 2,000 replications; p<0,05). AL = State of Alagoas; BA = State of Bahia; CE = State of Ceará; MA = State of Maranhão; PB = State of Paraiba; PE; State of Pernambuco; PI = State of Piauí; RN = State of Rio Grande do Norte; SE = State of Sergipe.

the most representative groups were amphibious and emergent, with 193 and 100 of the species, respectively. Next, there appeared rooted submersed (22 spp.), free floating (18 spp.), rooted floating (16 spp.), free submersed (eight spp.) and a single species of epiphyte. Relative to the plasticity of life forms, 47 species stood out for being amphibious as well as emergent. As for the results of the life forms per state, we also observed a higher number of species categorized as amphibious and emergent when compared to other analyzed categories (Figure 3). The other categories of life forms contained two species (amphibious/rooted floating) and only one species each (emergent/epiphyte/amphibious, emergent/free floating, emergent/rooted floating, emergent/rooted submerged and free floating/rooted floating). The predominance of species that presented amphibious and/or emergent life forms (for the nine states of Northeastern Brazil) was similar to results obtained in various aquatic environments of tropical regions (Pott and Pott 2000; Ferreira *et al.* 2011). We attribute the representativeness of these species to their morphophysiological adjustments, which allow them to survive in the interface between aquatic and terrestrial environments (Sculthorpe 1967; Matias *et al.* 2003). We further suggest that the high richness of amphibious and/or emergent aquatic plants in tropical ecosystems may be related to the number of species of Cyperaceae and Poaceae (Ribeiro *et al.* 2011).

In our list, 141 species were considered ruderal or opportunistic, corresponding to 34.2% of the number of aquatic macrophytes cited for the Northeast. Such species are grouped into 44 families, of which Poaceae (with 23 species), Asteraceae (14), Cyperaceae (14), Fabaceae (12) and Pontederiaceae (6) had the highest number of species (Table 2). Some studies have reported that the proliferation of aquatic ruderal weeds is primarily related to the dumping of industrial, urban and agricultural nutrient-rich nitrogen and phosphate (anthropogenic eutrophication) in rivers, lakes, ponds and reservoirs (Pott and Pott 2000; Esteves 2011). It is also known that eutrophication is an agent that interferes with interspecific interactions of natural selection, causing a decline in the biodiversity of aquatic communities (Tundisi and Tundisi 2008; Bicudo

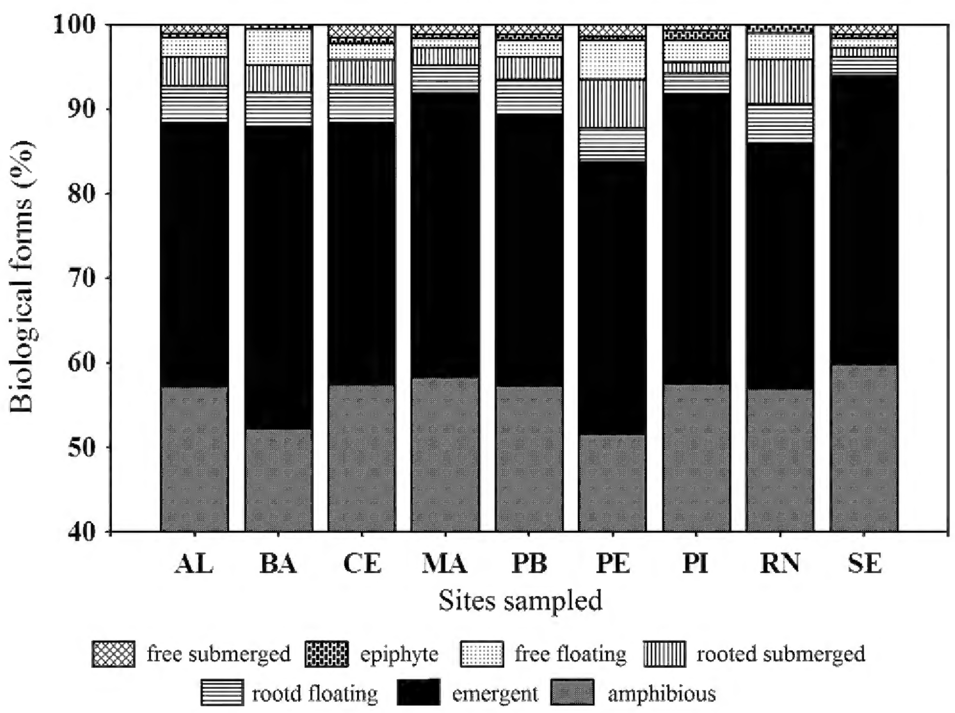

Figure 3. Life forms of aquatic macrophytes by state in Northeast Brazil. AL = State of Alagoas; BA = State of Bahia; CE = State of Ceará; MA = State of Maranhão; PB = State of Paraiba; PE; State of Pernambuco; PI = State of Piauí; RN = State of Rio Grande do Norte; SE = State of Sergipe.

et al. 2010; Esteves 2011). From this perspective, the growing process of deterioration in the quality of aquatic limnological ecosystems in Northeastern Brazil (Cyril *et al.* 2010; Silva and Zickel 2010) can be considered to be a factor threatening the aquatic biodiversity of the region, especially if academic studies and/or governmental strategies for the conservation of these resources are not developed.

The occurrence of ruderal species per state was the following: Maranhão (43.85%), Sergipe (42.85%), Alagoas (42.78%), Rio Grande do Norte (41.96%), Ceará (41.04%), Piauí (39.87%), Paraíba (39.31%), Bahia (36.16%) and Pernambuco (35.58%). It is worth pointing out that of the 71 species common to all states of the Northeast, 39 species were considered ruderal, while of the 41 taxa considered restricted, *i.e.*, that occurred only in a single state, six were ranked as ruderal (Table 2). As we observed in our study, other researchers also recorded a large percentage of ruderal species, e.g., Kita and Souza (2003) for the floodplain of the upper Paraná, Bove *et al.* (2003) in a temporary aquatic environment of the coastal plain in Rio de Janeiro, and Henry-Silva *et al.* (2010) for the hydrographic basin of Apodi/Mossoró, at 29%, 23% and 47.5%, respectively. The high representativeness of species considered ruderal or oportunistic can be attributed to some features favoring dispersion and survival, such as high adaptation and resistance, as well as longevity and good seed dispersion (Souza and Lorenzi 2008). In addition, the major weedy species of aquatic macrophytes that occur in Brazil spread vegetatively (plus via seed). This factor facilitates the proliferation and exaggerated abundance of some species in many aquatic environments. Many species thus become an ecological problem (Lembi 2009; Thomaz and Cunha 2010).

Moura *et al.* (2009) cited the weedy species *Egeria densa, Ceratophyllum demersum, Brachiaria mutica, B. subquadripara, Eichhornia crassipes, Pistia stratiotes, Polygonum lapathifolium, Echinochloa polystachya* and *Salvinia auriculata* as the species that have the most impact in the State of São Paulo because they can hinder multiple uses of water resources, such as the generation of electricity, irrigation, navigation, fishing and recreation. These species, except *Urochloa arrecta* (above cited as *Brachiaria subquadripara*, although not a synonym) and *Polygonum lapathifolium*, have all been recorded in Northeastern Brazil.

We verified that the existing aquatic flora in Northeastern Brazil exhibits high species richness, a fact that is easily observed by the number of recorded taxa. The record of species varied among states and among categories of life forms according to the amount of sampled areas and/or collection effort in each state. Although the Northeast presented a high richness of aquatic plants (34,2% of which were classified as ruderal), we observed a scarcity in the records of aquatic plants for the states of Alagoas, Rio Grande do Norte, Maranhão, Sergipe and Piauí. We detected a need for more data collection and research directed at the aquatic community. We suggest efforts on floristic and taxonomic work be performed in the Northeast of Brazil to gather information to better determine the contribution of aquatic macrophytes present in wetlands of this region.

Table 2. List of macrophytes by life forms (LF) and percent occurrence (PO%), recorded in the states of Northeast Brazil. (+) = occurrence; (-) = absence; (*) = ruderal specie; AL = State of Alagoas; BA = State of Bahia; CE = State of Ceará; MA = State of Maranhão; PB = State of Paraiba; PE; State of Pernambuco; PI = State of Piauí; RN = State of Rio Grande do Norte; SE = State of Sergipe; AM = amphibious; EM = emergent; EP = epiphyte; FF = free floating; FS = free submerged; RF = rooted floating; and RS = rooted submerged.

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Acanthaceae											
Dicliptera ciliaris Juss.	AM	-	+	+	-	+	+	-	+	-	0.23
Dyschoriste maranhonis Kuntze	EM	-	+	-	-	-	+	-	-	-	0.09
Hygrophila costata Nees	EM	-	+	-	-	-	+	-	-	+	0.14
Justicia aequilabris (Nees) Lindau	EM	-	+	+	-	+	+	-	+	-	0.23
Justicia laevilinguis (Ness) Lindau	AM	-	+	-	-	+	+	-	-	-	0.14
Nelsonia brunelloides (Lam.) Kuntz	AM	-	+	-	-	+	+	-	-	-	0.14
Ruellia bahiensis (Nees) Morong *	AM	+	+	+	-	+	+	-	+	+	0.32
Ruellia paniculata L.	AM	-	-	-	-	-	+	-	+	-	0.09
Aizoaceae											
Sesuvium portulacastrum (L.) L.	AM	+	+	+	+	+	+	-	+	+	0.37
Alismataceae											
Echinodorus andrieuxii (Hook et Arn.) Small	EM	-	+	+	-	-	+	+	-	-	0.18
Echinodorus floribundus (Seub.) Seub. *	EM	-	+	-	-	-	+	-	-	-	0.09
Echinodorus glandulosus Rataj *	EM	-	+	+	-	-	+	-	-	-	0.14
Echinodorus grandiflorus (Cham. and Schltdl.) Micheli *	EM	-	-	+	-	-	+	-	+	-	0.14
Echinodorus lanceolatus Rataj	EM	-	+	+	-	-	-	-	-	-	0.09
Echinodorus longipetalus Micheli	EM	-	+	+	+	+	+	+	+	+	0.37
Echinodorus macrophyllus (Kunth) Micheli	EM	+	+	+	-	+	-	-	-	-	0.18
Echinodorus palaefolius (Nees and Mart.) J.F. Macbr.	EM	-	+	-	-	-	-	-	-	-	0.05
Echinodorus paniculatus Micheli	EM	-	+	-	-	-	+	+	-	+	0.18
Echinodorus pubescens (Mart.) Seub. and Warm.	EM	-	+	+	-	+	+	+	-	+	0.27
Echinodorus ranunculoides (L.) Engelm.	EM	-	+	+	-	-	+	+	-	+	0.23
Echinodorus reticulatus R.R. Haynes and Holm-Niels.	EM	-	+	-	-	-	-	-	-	-	0.05
Echinodorus scaber Rataj	EM	-	+	+	+	-	+	+	-	+	0.27
Echinodorus subalatus (Mart.) Griseb.	EM	+	+	+	+	+	+	+	+	-	0.37
Echinodorus tenellus (Mart. ex Schult. and Schult. f.) Buchenau	AM	-	+	+	+	+	+	+	-	+	0.32
Hydrocleys martii Seub.	RF	+	+	+	-	+	+	+	+	-	0.32
Hydrocleys nymphoides (Willd.) Buchenau	RF	+	+	+	-	+	+	-	+	+	0.32
Hydrocleys parviflora Seub.	RF	-	-	-	-	-	-	-	+	-	0.05
Limnocharis flava (L.) Buchenau *	EM/AM	-	+	+	+	+	+	+	+	-	0.32
Sagittaria guayanensis Kunth *	EM	-	+	+	+	-	+	+	-	+	0.27
Sagittaria lancifolia L.	EM	+	+	-	-	+	-	-	-	+	0.18
Sagittaria planitiana G. Agostini	EM	-	+	+	-	-	-	-	-	-	0.09
Sagittaria rhombifolia Cham.	EM	-	+	-	-	-	+	-	-	-	0.09
Amaranthaceae											
Alternanthera philoxeroides (Mart.) Griseb. *	EM/AM	+	+	-	-	-	+	-	+	-	0.18
Alternanthera tenella Colla *	AM	+	+	+	+	+	+	+	+	+	0.41
Blutaparon portulacoides (A. St.-Hil.) Mears	AM	+	+	+	+	+	+	-	+	+	0.37
Gomphrena demissa Mart.	AM	-	+	+	-	+	+	+	+	+	0.32
Salicornia gaudichaudiana Moq.	AM	-	-	-	-	-	-	-	+	-	0.05
Apiaceae											
Centella asiatica (L.) Urb. *	AM	+	+	-	-	+	+	-	-	-	0.18
Lilaeopsis brasiliensis (Glaz.) Affolter	RS	-	-	-	-	-	+	-	-	-	0.05
Apocynaceae											
Ditassa hastata Decne.	AM	+	+	+	+	+	+	+	+	+	0.41
Araceae											
Lemna aequinoctialis Welw.	FF	+	+	+	-	-	+	+	+	-	0.27
Lemna gibba L.	FF	-	-	-	-	-	+	-	-	-	0.05
Lemna valdiviana Phil. *	FF	-	+	-	-	+	+	+	+	-	0.23
Montrichardia linifera (Arruda) Schott	EM	-	+	+	-	+	+	-	+	+	0.27
Philodendron rudgeanum Schott	EM	+	+	-	+	+	+	-	-	-	0.23
Pistia stratiotes L. *	FF	+	+	+	-	+	+	+	+	+	0.37
Spirodela intermedia W. Koch *	FF	-	-	-	-	-	+	-	-	-	0.05
Wolffia brasiliensis Wedd. *	FF	+	+	+	-	+	-	+	+	-	0.27
Wolffiella welwitschii (Hegelm.) Monod	FF	-	+	-	-	-	+	-	-	-	0.09

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Araliaceae											
Hydrocotyle bonariensis Lam. *	RF	+	+	+	-	-	+	-	+	-	0.23
Hydrocotyle leucocephala Cham. and Schltdl. *	RF	+	+	+	-	+	+	-	-	+	0.27
Hydrocotyle ranunculoides L.f.	EM	-	+	-	-	-	+	-	-	-	0.09
Asteraceae (Compositae)											
Acanthospermum hispidum DC. *	EM	+	+	+	+	+	+	+	+	+	0.41
Acmella uliginosa (Sw.) Cass.	AM	+	+	+	+	+	+	+	+	-	0.37
Ageratum conyzoides L. *	AM	+	+	+	+	+	+	+	+	+	0.41
Blainvillea dichotoma (Murray) Stewart	AM	+	+	+	+	+	-	+	+	+	0.37
Centratherum punctatum Cass. *	AM	+	+	+	+	+	+	+	+	+	0.41
Conyza bonariensis (L.) Cronquist *	AM	+	+	+	+	+	+	-	+	+	0.37
Delilia biflora (L.) Kuntze*	AM	+	+	+	+	+	+	-	+	+	0.37
Eclipta prostrata (L.) L. *	EM	+	+	+	+	+	+	+	+	+	0.41
Elephantopus mollis Kunth *	AM	+	+	+	+	+	+	+	-	-	0.32
Emilia coccinea (Sims) G. Don *	AM	-	-	-	-	-	+	-	-	-	0.05
Enydra radicans (Willd.) Lack.	AM	-	+	+	-	-	+	-	-	-	0.14
Enydra rivularis Gardner	AM	-	+	-	-	+	+	-	-	-	0.14
Gamochaeta americana (Mill.) Wedd. *	AM	-	+	-	-	-	+	-	-	-	0.09
Pluchea sagittalis (Lam.) Cabrera *	AM	+	+	+	+	+	+	-	-	+	0.32
Rolandra fruticosa (L.) Kuntze	AM	+	+	+	+	+	+	+	-	+	0.37
Sonchus oleraceus L. *	EM	+	+	+	-	+	+	-	-	-	0.23
Sphagneticola trilobata (L.) Pruski *	AM	+	+	+	+	+	+	+	+	+	0.41
Synedrella nodiflora (L.) Gaertn. *	AM	+	+	+	+	+	+	+	-	+	0.37
Vernonia scorpioides (Lam) Pers. *	AM	+	+	+	+	+	+	-	+	+	0.37
Wedelia alagoensis Baker	AM	+	+	-	-	-	+	-	-	-	0.14
Begoniaceae											
Begonia fischeri Schrank	AM	-	+	-	-	-	+	-	-	-	0.09
Begonia reniformis Dryand.	AM	+	+	+	-	+	+	-	-	+	0.27
Blechnaceae											
Blechnum brasiliense Desv.	EM	+	+	-	-	+	+	-	+	-	0.23
Boraginaceae											
Cordia curassavica (Jacq.) Roem. and Schult.	AM	-	+	-	-	-	-	-	-	-	
Cordia multispicata Cham.	AM	-	-	-	-	-	+	-	-	-	0.05
Cordia superba Cham.	AM	+	+	+	+	+	+	+	+	+	0.41
Heliotropium angiospermum Murray	AM	+	+	+	-	+	+	-	+	+	0.32
Heliotropium indicum L. *	AM	+	+	+	+	+	+	+	+	+	0.41
Heliotropium procumbens Mill. *	AM	+	+	+	+	+	+	+	+	+	0.41
Tournefortia bicolor Sw.	AM	+	+	-	+	+	+	-	+	-	0.27
Burmanniaceae											
Burmannia capitata (Walter ex J.F. Gmel.) Mart.	AM	+	+	+	-	+	+	+	+	+	0.37
Cabombaceae											
Cabomba aquatica Aubl.	RS	+	+	-	+	-	+	-	-	-	0.18
Cabomba furcata (Schult.) Schult. F.	FF	-	+	-	-	-	+	-	-	-	0.09
Campanulaceae											
Lobelia xalapensis Kunth	AM	-	+	-	-	+	+	-	-	-	0.14
Cannaceae											
Canna glauca L.	EM	-	+	+	+	+	+	-	-	+	0.27
Capparaceae											
Capparis flexuosa (L.) L.	AM	+	+	+	+	+	+	+	+	+	0.41
Caryophyllaceae											
Drymaria cordata (L.) Willd. ex Roem. and Schult. *	AM	+	+	+	-	+	+	-	-	+	0.27
Ceratophyllaceae											
Ceratophyllum demersum L. *	RS	-	-	+	-	-	-	-	+	-	0.09
Ceratophyllum submersum L.	RS	-	+	-	-	-	-	-	+	-	0.09
Characeae											
Chara zeylanica Willd.	RS	+	+	-	-	+	+	-	+	-	0.23
Cleomaceae											
Cleome guianensis Aubl.	AM	+	+	+	+	+	+	-	+	+	0.37
Cleome hassleriana Chodat *	AM	-	+	+	-	-	+	-	-	-	0.14
Cleome spinosa Jacq.*	AM	+	+	+	+	+	+	+	+	+	0.41

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Commelinaceae											
Callisia filiformis (M. Martens and Galeotti) D.R. Hunt	AM	+	+	+	-	+	+	-	+	-	0.27
Commelina erecta L. *	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Commelina schomburgkiana Klotzsch	AM	-	+	-	-	-	-	-	-	-	0.05
Convolvulaceae											
Aniseia cernua Moric.	AM	-	+	-	-	+	-	-	-	-	0.09
Evolvulus filipes Mart.	AM	+	+	+	+	+	+	+	+	+	0.41
Ipomoea asarifolia (Desr.) Roem. and Schult.*	EM/AM	+	+	+	+	+	+	+	+	-	0.37
Ipomoea carnea Jacq.	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Ipomoea fistulosa Mart. ex Choisy *	AM	+	+	+	-	-	+	+	-	-	0.23
Ipomoea setosa Ker Gawl. *	AM	-	+	+	-	+	-	-	+	+	0.23
Ipomoea wrightii A. Gray	AM	-	+	-	-	-	+	-	+	-	0.14
Merremia aegyptia (L.) Urb. *	AM	+	+	+	+	+	+	+	+	+	0.41
Merremia umbellata (L.) Hallier f. *	AM	+	+	+	+	+	+	-	+	+	0.37
Cucurbitaceae											
Fevillea trilobata L.	AM	-	+	+	-	+	+	-	-	-	0.18
Cymodoceaceae											
Halodule emarginata Hartog	RS	-	-	-	-	-	+	-	-	-	0.05
Halodule wrightii Asch.	RS	-	+	+	-	-	+	-	+	-	0.18
Cyperaceae											
Becquerelia cymosa Brongn.	AM	+	+	+	+	+	+	-	-	+	0.32
Bulbostylis capillaris (L.) Kunth ex C.B. Clarke *	AM	+	+	+	+	+	+	+	+	+	0.41
Bulbostylis hirtella (Schrad. ex Schult.) Nees ex Urb.	AM	-	+	+	-	+	-	-	-	-	0.14
Bulbostylis junciformis (Kunth) C.B. Clarke	AM	+	+	+	+	+	+	+	+	+	0.41
Cladium jamaicense Crantz	EM	-	+	-	-	+	+	-	-	-	0.14
Cyperus aggregatus (Willd.) Endl.	AM	+	+	+	+	+	+	+	+	+	0.41
Cyperus amabilis Vahl	AM	+	+	+	+	+	+	-	+	-	0.32
Cyperus articulatus L.	AM	+	+	+	+	+	+	+	+	+	0.41
Cyperus cayennensis Willd. ex Link	EM/AM	-	+	-	-	-	-	-	-	-	0.05
Cyperus compressus L.	EM	+	+	+	+	+	+	+	+	+	0.41
Cyperus cuspidatus Kunth	AM	+	+	+	-	+	+	+	+	+	0.37
Cyperus esculentus L. *	EM/AM	-	+	-	-	-	-	-	+	-	0.09
Cyperus gardneri Nees	EM	-	-	-	+	-	+	-	+	-	0.14
Cyperus giganteus Vahl *	EM	-	+	+	-	-	+	-	-	-	0.14
Cyperus haspan L.	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Cyperus hermaphroditus (Jacq.) Standl.	EM/AM	+	+	+	-	+	+	-	+	+	0.32
Cyperus imbricatus Retz.	EM	-	+	+	+	+	+	-	-	-	0.23
Cyperus involucratus Rottb.	EM	-	-	-	-	-	+	-	-	-	0.05
Cyperus iria L.	EM	+	+	+	+	-	+	+	+	+	0.37
Cyperus lanceolatus Poir. *	EM	-	+	-	-	+	-	-	-	-	0.09
Cyperus laxus Lam.	EM	+	+	+	+	+	+	+	+	+	0.41
Cyperus ligularis L.	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Cyperus luzulae (L.) Rottb. ex Retz. *	EM	+	+	+	+	+	+	+	+	+	0.41
Cyperus odoratus L. *	EM	+	+	+	+	+	+	-	+	+	0.37
Cyperus papyrus L.	EM	+	-	-	-	-	+	+	-	+	0.18
Cyperus surinamensis Rottb.	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Cyperus uncinulatus Schrad. ex Nees	EM	+	+	+	-	+	+	+	+	+	0.37
Cyperus virens Michx.	EM/AM	-	+	-	-	-	+	-	+	-	0.14
Dialium guianense (Aubl.) Sandwith	AM	+	+	-	+	+	+	-	-	-	0.23
Diplacrum longifolium (Griseb.) C.B. Clarke	AM	-	+	-	+	+	+	-	-	-	0.18
Eleocharis acutangula (Roxb.) Schult. *	AM	-	+	+	+	+	+	-	+	+	0.32
Eleocharis atropurpurea (Retz.) J. Presl and C. Presl	AM	+	+	+	-	+	+	-	-	-	0.23
Eleocharis barrosii Svenson	AM	-	+	+	-	+	+	-	-	-	0.18
Eleocharis elata Boeckeler	AM	-	+	+	-	-	+	+	-	-	0.18
Eleocharis filiculmis Kunth	AM	-	+	-	+	+	+	+	+	+	0.32
Eleocharis flavescens (Poir.) Urban	EM	-	+	+	-	+	+	-	-	+	0.23
Eleocharis geniculata (L.) Roem. and Schult.	AM	+	+	+	+	+	+	+	+	+	0.41
Eleocharis interstincta (Vahl) Roem. and Schult. *	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Eleocharis maculosa (Vahl) Roem. and Schult.	EM	-	+	+	-	+	+	-	-	+	0.23
Eleocharis minima Kunth	EM/AM	+	+	+	+	+	+	+	+	-	0.37

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Eleocharis mutata (L.) Roem.and Schult.	EM/RS	+	+	+	+	+	+	+	+	+	0.41
Eleocharis nodulosa (Roth) Schult.	EM/AM	-	+	+	-	-	-	-	-	-	0.09
Eleocharis sellowiana Kunth *	AM	-	+	+	+	+	+	-	-	-	0.23
Fimbristylis autumnalis (L.) Roem. and Schult. *	EM	+	+	-	-	-	+	-	-	-	0.14
Fimbristylis cymosa R. Br.	AM	+	+	+	+	+	+	+	+	+	0.41
Fimbristylis diphylla (Reitz) Vahl *	EM	-	+	-	-	-	+	-	-	-	0.09
Fuirena umbellata Rottb.	EM/AM	+	+	+	+	+	+	-	+	+	0.37
Kyllinga pumila Michx.	AM	-	+	+	+	+	+	-	-	+	0.27
Kyllinga vaginata Lam.	AM	+	+	+	-	+	+	+	+	+	0.37
Lipocarpha micrantha (Vahl) G.C. Tucker	AM	+	+	+	-	+	+	+	+	+	0.37
Oxycaryum cubense (Poepp. and Kunth) Palla	EM/AM/EP	-	+	+	+	+	+	+	+	-	0.32
Pycreus flavescens (L.) P. Beauv. ex Rchb.	AM	-	+	+	-	-	+	+	-	-	0.18
Pycreus macrostachyos (Lam.) J. Raynal	EM	+	+	+	-	+	+	+	+	+	0.37
Pycreus polystachyos (Rottb.) P. Beauv. *	EM/AM	+	+	+	+	+	+	-	+	+	0.37
Rhynchospora cephalotes (L.) Vahl	EM	+	+	+	+	+	+	+	+	+	0.41
Rhynchospora contracta (Nees) J. Raynal	EM	+	+	+	-	+	+	-	+	+	0.32
Rhynchospora corymbosa (L.) Britton *	EM	+	+	+	+	-	+	-	-	+	0.27
Rhynchospora cyperoides Mart.	AM	-	-	+	-	-	-	-	-	-	0.05
Rhynchospora gigantea Link	EM	+	+	-	-	+	+	-	-	+	0.23
Rhynchospora holoschoenoide (Rich.) Herter	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Rhynchospora pubera (Vahl) Boeckeler	EM	+	+	-	+	+	+	+	-	-	0.27
Rhynchospora riparia (Nees) Boeckeler	AM	+	+	+	+	+	+	+	+	+	0.41
Rhynchospora tenerrima Nees ex Spreng.	EM	-	+	-	+	+	+	+	+	+	0.32
Rhynchospora tenuis Willd. ex Link	EM	-	+	+	+	+	+	+	-	+	0.32
Rhynchospora trispicata (Nees) Schrad. ex Steud.	EM	-	+	-	+	-	+	-	-	-	0.14
Scleria bracteata Cav.	EM	+	+	+	+	+	+	-	+	+	0.37
Scleria hirtella Sw.	AM	-	+	+	-	-	+	+	+	+	0.27
Scleria latifolia Sw.	EM	+	+	+	+	+	+	-	-	+	0.32
Scleria melalaeuca Rchb. ex Schldl. and Cham. *	AM	-	-	-	-	-	+	-	-	-	0.05
Websteria confervoides (Poir.) S.S. Hooper	RS	+	-	-	-	+	+	-	-	-	0.14
Eriocaulaceae											
Eriocaulon aquatile Körn.	AM	-	-	-	-	-	+	-	-	-	0.05
Leiothrix pilulifera (Körn.) Ruhland	AM	+	+	-	-	+	+	-	-	+	0.23
Euphorbiaceae											
Euphorbia hyssopifolia L. *	AM	+	+	+	+	+	+	+	+	+	0.41
Euphorbia thymifolia L.	AM	-	-	-	-	-	+	-	-	-	0.05
Tonina fluviatilis Aubl.	AM	+	+	+	+	+	+	+	+	-	0.37
Fabaceae											
Aeschynomene evenia C. Wright and Sauvalle	EM	+	+	+	+	+	+	+	-	+	0.37
Aeschynomene filosa Mart.	AM	-	+	+	+	+	+	+	+	-	0.32
Aeschynomene sensitiva Sw.	AM	+	+	+	+	+	+	+	-	+	0.37
Anadenanthera colubrina (Vell.) Brenan	AM	+	+	+	+	+	+	+	+	+	0.41
Centrosema brasilianum (L.) Benth.	AM	+	+	+	+	+	+	+	+	+	0.41
Centrosema pubescens Benth.	AM	+	+	+	+	+	+	+	-	-	0.32
Chamaecrista repens (Vogel) H.S. Irwin and Barneby	EM	+	+	+	+	+	+	+	-	+	0.37
Desmodium barbatum (L.) Benth. *	AM	+	+	+	+	+	+	+	+	+	0.41
Desmodium incanum DC. *	AM	+	+	+	+	+	+	+	+	+	0.41
Desmodium tortuosum (Sw.) DC. *	AM	-	+	+	+	+	+	+	+	-	0.32
Dioclea grandiflora Mart. ex Benth.	EP	+	+	+	-	+	+	+	+	+	0.37
Indigofera hirsuta L. *	AM	+	+	+	+	-	+	-	-	-	0.23
Lonchocarpus sericeus (Poir.) Kunth ex DC.	AM	+	+	+	+	+	+	+	+	+	0.41
Macroptilium lathyroides (L.) Urban *	AM	+	+	+	+	+	+	+	+	+	0.41
Mimosa bimucronata (DC.) Kuntze	AM	-	+	-	-	-	+	-	-	-	0.09
Mimosa pudica L. *	AM	+	+	-	-	+	+	-	+	+	0.27
Neptunia plena (L.) Benth. *	AM	+	+	+	+	+	+	+	+	-	0.37
Rhynchosia minima (L.) DC.	AM	-	+	+	+	+	+	+	+	-	0.32
Senna obtusifolia (L.) H.S. Irwin and Barneby *	EM	+	+	+	+	+	+	+	+	+	0.41
Senna uniflora (Mill.) H.S. Irwin and Barneby *	AM	-	+	+	+	+	+	-	-	-	0.23
Stylosanthes angustifolia Vogel	AM	-	+	+	+	+	+	+	+	+	0.37
Stylosanthes gracilis Kunth *	AM	+	+	+	+	+	+	+	+	+	0.41

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Stylosanthes guianensis (Aubl.) Sw. *	AM	+	+	+	+	+	+	+	+	+	0.41
Stylosanthes scabra Vogel	AM	+	+	+	+	+	+	+	+	+	0.41
Stylosanthes viscosa (L.) Sw. *	AM	+	+	+	+	+	+	+	+	+	0.41
Vigna luteola (Jacq.) Benth.	AM	-	+	-	-	-	-	-	-	-	0.05
Zornia latifolia Sm.	AM	-	-	+	-	-	-	-	-	-	0.05
Gentianaceae											
Irlbachia alata (Aubl.) Maas	AM	+	+	-	+	+	+	-	-	-	0.23
Irlbachia purpurascens (Aubl.) Maas	AM	+	+	+	-	+	+	-	+	+	0.32
Schultesia guianensis (Aubl.) Malme	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Haloragaceae											
Laurembergia tetrandra (Schott) Kanitz	RS	-	+	-	-	-	+	-	-	-	0.09
Myriophyllum aquaticum (Vell.) Verdc. *	RS	+	+	-	-	-	+	-	-	-	0.14
Hydrocharitaceae											
Apalanthe granatensis (Bonpl.) Planch.	RS	-	+	+	+	+	+	-	+	-	0.27
Egeria densa Planch. *	RS	-	-	+	-	+	+	-	-	+	0.18
Elodea canadensis Michx.	RS	-	-	-	-	-	+	-	-	-	0.05
Halophila decipiens Ostenf.	RS	-	+	-	-	-	+	-	+	-	0.14
Limnobium laevigatum (Humb. and Bonpl. ex Willd.) Heine	FF	-	+	-	-	-	+	-	-	-	0.09
Najas conferta (A. Braun) A. Braun	FS	-	+	+	-	-	+	-	-	-	0.14
Najas guadalupensis (Spreng.) Magnus	FS	-	+	-	-	-	-	-	-	-	0.05
Najas marina L.	RS	-	+	-	-	-	+	-	-	-	0.09
Hydroleaceae											
Hydrolea spinosa L. *	EM	+	+	+	+	+	+	+	+	+	0.41
Juncaceae											
Juncus microcephalus Kunth *	AM	-	+	-	-	-	+	-	-	-	0.09
Lamiaceae											
Hyptis atrorubens Poit. *	AM	+	+	+	+	+	+	+	-	+	0.37
Hyptis suaveolens (L.) Poit.*	AM	+	+	+	+	+	+	+	+	+	0.41
Marsypianthes chamaedrys (Vahl) Kuntze *	AM	+	+	+	+	+	+	+	+	+	0.41
Ocimum campechianum Mill. *	AM	+	+	+	+	+	-	+	-	+	0.32
Vitex megapotamica (Spreng.) Moldenke	AM	-	+	-	-	+	+	+	-	-	0.18
Lentibulariaceae											
Genlisea filiformis A. St.-Hil.	AM	-	+	-	-	+	+	-	-	-	0.14
Utricularia adpressa Salzm. ex A. St.-Hil. and Girard	AM	-	+	+	-	-	-	-	-	-	0.09
Utricularia breviscapa Wright ex Griseb.	FS	-	+	-	-	-	-	-	-	-	0.05
Utricularia foliosa L. *	FS	+	+	+	+	+	+	+	+	+	0.41
Utricularia gibba L.	AM	+	+	+	-	+	+	-	+	-	0.27
Utricularia hydrocarpa Vahl	FS	-	+	+	+	+	+	-	-	-	0.23
Utricularia juncea Vahl	FS	+	+	-	-	+	+	-	-	-	0.18
Utricularia laciniata A. St.-Hil. and Girard	FS	-	-	-	-	-	+	-	-	-	0.05
Utricularia pusilla Vahl	AM	+	+	-	-	-	+	-	-	+	0.18
Utricularia trichophylla Spruce ex. Oliver	FS	-	+	+	-	-	-	-	-	+	0.14
Linderniaceae											
Lindernia crustacea (L.) F. Muell.	AM	+	-	+	+	+	+	-	-	+	0.27
Lindernia microcalyx Pennell and Stehlé	AM	+	+	+	-	-	+	-	-	-	0.18
Lindernia rotundifolia (L.) Alston	AM	-	+	-	-	-	+	-	-	-	0.09
Torenia thouarsii (Cham. and Schltdl.) Kuntze	EM/AM	-	+	-	-	-	+	-	+	+	0.18
Loganiaceae											
Spigelia anthelmia L. *	AM	+	+	+	+	+	+	+	+	+	0.41
Lythraceae											
Ammannia latifolia L.	AM	-	+	+	-	+	+	-	+	-	0.23
Cuphea campestris Koehne	EM/AM	-	+	+	-	+	+	+	+	-	0.27
Cuphea carthagenensis (Jacq.) J.F. Macbr. *	EM/AM	-	+	+	-	-	+	-	-	+	0.18
Cuphea circaeoides Sm. ex Sims	EM/AM	+	+	+	-	-	+	-	+	-	0.23
Cuphea racemosa (L.f.) Spreng. *	EM	+	+	-	-	+	+	-	-	+	0.23
Pleurophora anomala (A. St.-Hil.) Koehne	EM/AM	+	+	+	-	+	+	+	+	+	0.37
Rotala mexicana Schltdl. and Cham.	EM	-	+	-	-	-	-	-	-	-	0.05
Rotala ramosior (L.) Koehne	AM	-	+	-	-	+	+	-	-	-	0.14
Malvaceae											
Corchorus hirtus L.	AM	+	+	+	+	+	+	-	-	+	0.32

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Pavonia cancellata (L.) Cav. *	AM	+	+	+	+	+	+	+	+	+	0.41
Sida anomala A. St. Hil.	AM	-	+	+	+	+	-	+	+	-	0.27
Sida galheirensis Ulbr.	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Sida spinosa L. *	AM	+	+	+	+	+	+	+	+	+	0.41
Sidastrum multiflorum (Jacq.) Fryxell	EM	-	+	+	-	+	+	-	-	-	0.18
Triumfetta althaeoides Lam.	EM	+	+	+	+	+	+	-	-	-	0.27
Urena lobata L. *	EM	+	+	+	+	+	+	+	+	+	0.41
Waltheria indica L. *	AM	-	-	+	-	-	-	-	-	-	0.05
Marantaceae											
Thalia geniculata L. *	EM	-	+	+	+	+	+	-	+	-	0.27
Marsileaceae											
Marsilea crotophora D.M. Johnson	RF	-	+	-	-	-	-	-	-	-	0.05
Marsilea deflexa A Braun	AM/RF	-	+	-	-	-	+	-	-	-	0.09
Mayacaceae											
Mayaca fluviatilis Aubl.	RS	-	+	-	-	-	+	-	+	-	0.14
Melastomataceae											
Clidemia hirta (L.) D. Don	AM	+	+	+	+	+	+	+	+	+	0.41
Menyanthaceae											
Nymphoides indica (L.) Kuntze *	RF	+	+	+	+	+	+	+	+	+	0.41
Molluginaceae											
Mollugo verticillata L. *	EM	+	+	+	+	+	+	+	+	+	0.41
Nymphaeaceae											
Nymphaea alba L.	RF	-	-	-	-	+	+	+	+	-	0.18
Nymphaea amazonum Mart. and Zucc.	RF	-	+	+	+	+	+	+	+	-	0.32
Nymphaea ampla (Salisb.) DC. *	RF	+	+	+	+	+	+	-	+	-	0.32
Nymphaea capensis Thunb.	RF	-	-	-	-	-	+	-	-	-	0.05
Nymphaea lasiophylla Mart. and Zucc.	RF	+	+	+	-	+	+	-	-	+	0.27
Nymphaea rudgeana G. Mey.	RF	-	+	+	+	+	+	-	-	-	0.23
Ochnaceae											
Sauvagesia erecta L.	EM	+	+	+	+	+	+	+	+	+	0.41
Onagraceae											
Ludwigia erecta (L.) H. Hara	EM/AM	+	+	+	-	+	+	-	+	+	0.32
Ludwigia filiformis (Micheli) Ramamoorthy	AM	-	+	-	-	-	-	-	-	-	0.05
Ludwigia helminthorrhiza (Mart.) H. Hara	RF/FF	-	+	+	+	+	+	-	+	-	0.27
Ludwigia inclinata (L.f.) M. Gómez	AM/RF	-	+	-	+	-	-	-	-	-	0.09
Ludwigia leptocarpa (Nutt.) H. Hara *	AM	-	+	+	+	+	+	+	+	+	0.37
Ludwigia linifolia Poir.	EM	-	-	-	-	-	+	+	-	-	0.09
Ludwigia octovalvis (Jacq.) P.H. Raven *	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Ludwigia peploides (Kuntze) P.H. Raven	AM	-	+	-	-	+	+	-	+	-	0.18
Ludwigia suffruticosa Walter *	EM	-	-	-	-	-	+	-	+	-	0.09
Orchidaceae											
Anacheilium alagoense (Pabst) Pabst, Moutinho ex A.V. Pinto	EM/AM	-	-	-	-	-	+	-	-	-	0.05
Epidendrum tridactylum Lindl.	EM/AM	-	+	-	-	-	+	-	-	-	0.09
Habenaria pratensis (Lindl.) Rchb. f.	EM	+	+	-	+	+	+	+	-	+	0.32
Habenaria repens Nutt.	EM	-	+	-	-	+	+	-	-	-	0.14
Orobanchaceae											
Melasma melampyroides (Rich.) Pennell	EM/AM	-	+	-	+	+	+	-	-	+	0.23
Passifloraceae											
Piriqueta racemosa (Jacq.) Sweet	AM	-	+	-	-	+	-	-	-	-	0.09
Plantaginaceae											
Angelonia gardneri Hook.	EM	+	+	+	-	+	+	-	+	+	0.32
Bacopa aquatica Aubl.	EM/AM	+	+	+	-	-	+	+	-	-	0.23
Bacopa monnieri (L.) Wettst.	AM	-	+	+	+	+	+	-	+	+	0.32
Bacopa stricta (Schrad.) Edwall	AM	-	+	-	-	-	+	-	-	-	0.09
Micranthemum umbrosum (J.F. Gmel.) S.F. Blake *	AM	-	+	+	-	+	+	-	-	-	0.18
Scoparia dulcis L.*	AM	+	+	+	+	+	+	+	+	+	0.41
Stemodia durantifolia (L.) Sw.	EM	-	+	+	+	+	+	-	-	-	0.23
Stemodia maritima L.	AM	+	+	+	+	+	+	+	+	+	0.41
Stemodia pratensis (Aubl.) C.C. Cowan	AM	+	+	+	-	+	+	-	+	-	0.27

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Poaceae											
Anthephora hermaphrodita (L.) Kuntze	AM	+	+	+	-	+	+	+	+	+	0.37
Brachiaria brizantha (Hochst. Ex A.Rich.) Stapf *	EM	-	+	-	-	+	+	-	-	-	0.14
Brachiaria decumbens (Stapf) R.D. Webster*	AM	-	+	+	-	-	+	-	+	-	0.18
Brachiaria mutica (Forssk.) Stapf *	EM	+	+	-	-	+	+	-	-	-	0.18
Brachiaria plantaginea (Link) Hitchc. *	EM	-	+	+	+	+	+	+	-	-	0.27
Cenchrus echinatus L.*	AM	+	+	+	+	+	+	+	+	+	0.41
Chloris barbata Sw. *	EM/AM	+	+	+	-	+	+	+	+	+	0.37
Chloris exilis Renvoize	AM	+	+	-	+	-	+	-	-	-	0.18
Cynodon dactylon (L.) Pers. *	EM	+	+	+	+	+	+	+	+	-	0.37
Dactyloctenium aegyptium (L.) Willd. *	EM	+	+	+	+	+	+	+	+	+	0.41
Digitaria ciliaris (Retz.) Koeler *	EM	+	+	+	+	+	+	+	+	+	0.41
Echinochloa colona (L.) Link *	EM/AM	+	+	+	+	+	+	+	+	+	0.41
Echinochloa crus-pavonis (Kunth) Schult. *	AM	-	+	+	-	+	+	-	-	-	0.18
Echinochloa polystachya (Kunth) Hitchc. *	EM	+	+	+	+	+	+	+	+	-	0.37
Eragrostis pilosa (L.) P. Beauv. *	AM	-	+	+	-	+	+	+	+	+	0.32
Eriochloa punctata (L.) Desv. ex Ham. *	AM	+	+	+	+	+	+	-	+	+	0.37
Heleochloa schoenoides (L.) Host	AM	-	-	-	-	-	+	-	-	-	0.05
Homolepis isocalycia (G. Mey.) Chase	EM	+	+	+	-	-	+	-	-	+	0.23
Hymenachne amplexicaulis (Rudge) Nees *	EM/AM	-	+	+	+	+	+	+	+	-	0.32
Leersia hexandra Sw. *	EM	-	+	-	-	-	+	-	-	-	0.09
Leptochloa fascicularis (Lam.) A. Gray	EM	+	+	+	-	+	+	+	+	-	0.32
Luziola brasiliana Moric.	EM/AM	-	+	+	-	+	+	+	-	-	0.23
Oryza sativa L. *	AM	+	-	-	+	+	+	-	-	-	0.18
Panicum aquaticum Poir. *	EM	-	+	+	+	+	+	-	-	-	0.23
Panicum boliviense Hack.	EM/AM	-	+	-	-	+	-	-	-	-	0.09
Panicum dichotomiflorum Michx. *	EM	-	+	+	+	+	+	-	+	-	0.27
Panicum maximum Jacq. *	EM/AM	+	+	+	+	+	+	-	+	+	0.37
Panicum milleflorum Hitchc. and Chase	AM	-	-	+	+	-	+	-	-	-	0.14
Panicum parvifolium Lam.	EM	+	+	-	+	+	+	+	-	+	0.32
Paratheria prostrata Griseb.	EM	-	-	-	-	-	+	-	-	-	0.05
Paspalidium geminatum (Forssk.) Stapf	EM/AM	-	+	+	+	+	+	+	+	-	0.32
Paspalum millegrana Schrad.	EM	+	+	+	+	+	+	+	+	+	0.41
Paspalum repens P.J. Bergius *	EM	+	+	+	-	+	+	-	-	-	0.23
Paspalum vaginatum Sw.	AM	+	+	+	+	+	+	+	+	+	0.41
Setaria parviflora (Poir.) Kerguélen.	EM	+	+	+	-	+	+	-	+	+	0.32
Sporobolus indicus (L.) R.BR. *	EM	-	+	-	+	+	+	-	+	+	0.27
Podostemaceae											
Apinagia richardiana (Tul.) P. Royen	RS	+	-	+	-	-	+	-	-	-	0.14
Mourera fluviatilis Aubl.	RS	+	-	-	+	-	+	-	-	-	0.14
Tristicha trifaria (Bory ex Willd.) Spreng.	RS	-	-	+	-	-	+	-	-	-	0.09
Polygonaceae											
Coccoloba confusa R.A. Howard	EM/AM	+	+	+	-	-	+	-	-	+	0.23
Coccoloba ochreolata Wedd.	EM/AM	+	+	-	-	-	+	+	-	+	0.23
Polygonum acre Lam.	AM	+	+	-	-	-	+	-	-	-	0.14
Polygonum ferrugineum Wedd.	EM/AM	+	+	+	+	+	+	-	-	-	0.27
Polygonum hispidum Kunth	EM/AM	-	+	+	+	+	+	+	+	+	0.37
Polygonum hydropiperoides Michx. *	EM/RF	-	+	+	-	+	+	+	-	+	0.27
Polygonum punctatum Elliott	AM	+	+	+	-	+	+	+	-	+	0.32
Ruprechtia laxiflora Meisn.	AM	+	+	+	-	+	+	-	-	+	0.27
Triplaris gardneriana Wedd.	AM	+	+	+	+	+	+	+	+	+	0.41
Pontederiaceae											
Eichhornia azurea (Sw.) Kunth *	FF	-	+	-	-	-	+	-	-	-	0.09
Eichhornia crassipes (Mart.) Solms *	EM/FF	+	+	+	+	+	+	-	+	-	0.32
Eichhornia diversifolia (Vahl) Urb.	RF	-	+	+	+	+	+	-	-	-	0.23
Eichhornia heterosperma Alexander	AM	-	+	+	-	+	+	+	+	-	0.27
Eichhornia paniculata (Spreng.) Solms *	EM/AM	+	+	+	-	+	+	-	+	+	0.32
Heteranthera limosa (Sw.) Willd. *	AM	+	+	+	+	+	+	+	+	+	0.41
Heteranthera oblongifolia C. Mart. ex Roem. and Schult.	AM	+	+	+	+	+	+	+	+	+	0.41
Heteranthera reniformis Ruiz and Pav. *	RF	+	+	+	-	-	+	-	-	-	0.18

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Heteranthera seubertiana Solms	AM	-	-	+	-	-	+	-	+	-	0.14
Hydrothrix gardneri Hooker F.	RS	-	+	+	-	+	+	+	+	-	0.27
Pontederia cordata L. *	EM	+	+	+	+	+	+	+	-	-	0.32
Portulacaceae											
Portulaca marginata Kunth *	AM	-	+	-	-	-	-	-	-	-	0.05
Potamogetonaceae											
Potamogeton polygonus Cham. and Schltdl.	RS	-	-	-	-	-	+	-	-	-	0.05
Pteridaceae											
Acrostichum aureum L.	AM	-	+	+	+	+	+	-	+	+	0.32
Acrostichum danaeifolium Langsd. and Fisch.	AM	-	+	-	+	-	+	-	-	-	0.14
Ceratopteris pteridoides (Hook.) Hieron.	EM/AM	-	+	+	+	-	+	+	-	-	0.23
Ceratopteris thalictroides (L.) Brongn.	EM/AM	-	+	-	-	-	+	-	-	-	0.09
Pityrogramma calomelanos (L.) Link	EM/AM	-	+	+	+	-	+	-	-	-	0.18
Pteris vittata L. *	AM	-	-	-	-	-	+	-	-	-	0.05
Ricciaceae											
Ricciocarpos natans (L.) Corda	RF	+	+	-	-	-	-	-	-	-	0.09
Rubiaceae											
Borreria alata (Aubl.) DC.	AM	-	-	-	-	-	+	-	+	-	0.09
Borreria scabiosoides Cham. and Schltdl.	AM	-	+	+	-	+	+	+	-	-	0.23
Borreria verticillata (L.) G. Mey. *	AM	-	+	+	-	-	-	-	-	-	0.09
Coutarea hexandra (Jacq.) K. Schum.	AM	-	-	+	+	-	+	+	-	-	0.18
Machaonia spinosa Cham. and Schltdl.	AM	-	-	-	-	-	+	-	-	-	0.05
Mapouria corymbifera Müll. Arg.	AM	-	-	-	-	-	+	-	-	-	0.05
Pentodon pentandrus (Schumach. and Thonn.) Vatke	AM	-	+	-	-	-	+	-	-	-	0.09
Psychotria deflexa DC.	AM	+	+	+	+	-	+	-	+	-	0.27
Psychotria erecta (Aubl.) Standl. and Steyerm.	AM	-	+	+	-	+	+	-	-	+	0.23
Ruppiaceae											
Ruppia maritima L.	RS	-	-	-	-	+	+	-	+	-	0.14
Salviniaceae											
Azolla caroliniana Willd. *	FF	-	+	-	-	-	+	-	-	-	0.09
Azolla filiculoides Lam.	FF	-	+	-	-	-	+	-	-	-	0.09
Azolla microphylla Kaulf.	FF	-	-	-	-	-	+	-	-	-	0.05
Salvinia auriculata Aubl. *	FF	+	+	+	+	+	+	-	+	+	0.37
Salvinia biloba Raddi	FF	-	-	-	-	-	+	-	-	-	0.05
Salvinia martynii Kopp.	FF	-	+	-	-	-	-	-	-	-	0.05
Salvinia minima Baker	FF	-	+	-	-	-	+	-	-	-	0.09
Salvinia oblongifolia Martius	FF	-	+	-	-	-	+	-	-	-	0.09
Solanaceae											
Brunfelsia uniflora (Pohl) D. Don	AM	+	+	+	-	-	+	+	-	-	0.23
Nicotiana glauca Graham	AM	+	+	+	-	+	+	-	+	-	0.27
Physalis pubescens L. *	AM	-	+	+	-	-	-	-	-	+	0.14
Solanum asperum Rich. *	AM	+	+	+	+	+	+	+	-	-	0.32
Solanum baturitense Huber	AM	+	+	+	+	+	+	-	-	-	0.27
Solanum capsicoides All. *	AM	-	+	+	-	+	+	-	-	+	0.23
Solanum paludosum Moric.	AM	+	+	+	+	+	+	-	-	+	0.32
Solanum paniculatum L. *	AM	-	+	+	+	-	+	-	+	+	0.27
Solanum stipulaceum Roem. and Schult. *	AM	+	+	+	-	+	+	+	-	+	0.32
Sphenocleaceae											
Sphenoclea zeylanica Gaertn. *	AM	-	-	+	+	-	+	-	-	-	0.14
Thelypteridaceae											
Thelypteris interrupta (Willd.) K. Iwats.	EM/AM	+	+	-	+	-	+	-	-	-	0.18
Typhaceae											
Typha domingensis Pers. *	EM	-	+	-	-	-	+	-	-	-	0.09
Urticaceae											
Cecropia adenopus Mart. ex Miq. *	AM	-	+	-	-	-	+	-	-	-	0.09
Verbenaceae											
Lantana camara L. *	AM	+	-	+	+	+	+	-	-	+	0.27
Priva bahiensis A. DC. *	AM	+	+	-	-	+	+	-	-	+	0.23
Priva lappulacea (L.) Pers.	AM	-	-	-	-	-	+	-	-	-	0.05
Stachytarpheta cayennensis (Rich.) Vahl *	AM	-	+	-	+	-	+	-	-	-	0.14

Table 2. *Continued.*

FAMILY/SPECIES	LF	AL	BA	CE	MA	PB	PE	PI	RN	SE	PO %
Stachytarpheta elatior Schrad. ex Schult. *	AM	-	+	-	-	-	+	-	-	-	0.09
Xyridaceae											
Xyris anceps Lam.	EM	+	-	+	-	+	+	-	-	-	0.18
Xyris capensis Thunb.	EM	-	-	-	-	-	+	-	-	-	0.05
Xyris fallax Malme	EM	-	+	-	-	-	+	-	-	-	0.09
Xyris jupicai Rich.	EM	-	+	-	+	+	+	-	-	+	0.23
Xyris laxifolia Mart.	AM	-	+	+	-	-	-	-	-	-	0.09
Zingiberaceae											
Hedychium coronarium J. König *	EM	+	+	-	-	+	+	-	-	-	0.18

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Aquatic macrophytes of Northeastern Brazil: Checklist, richness, distribution and life forms

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ERRATUM

Authors affiliation: Liliane Ferreira Lima [1], Simone Santos Lira Silva [2] **should be** Liliane Ferreira Lima [2], Simone Santos Lira Silva [5]

Abstract: Species richness in Pernambuco **should be** 369, not 370.

Page 310 within **Table 2:**

Salviniaceae												
Salvinia biloba Raddi	FF	-	-	-	-	-	+	-	-	-	0.05
Salvinia martynii Kopp.	FF	-	+	-	-	-	-	-	-	-	0.05

Should be

Salviniaceae												
Salvinia biloba Raddi	FF	-	+	-	-	-	+	-	-	-	0.09
Salvinia martynii Kopp.	FF	-	-	-	+	-	-	-	-	-	0.05

We regret these errors.

May 2013